Interactions between CO, OH, and CH4: Global Warming Potentials for CO

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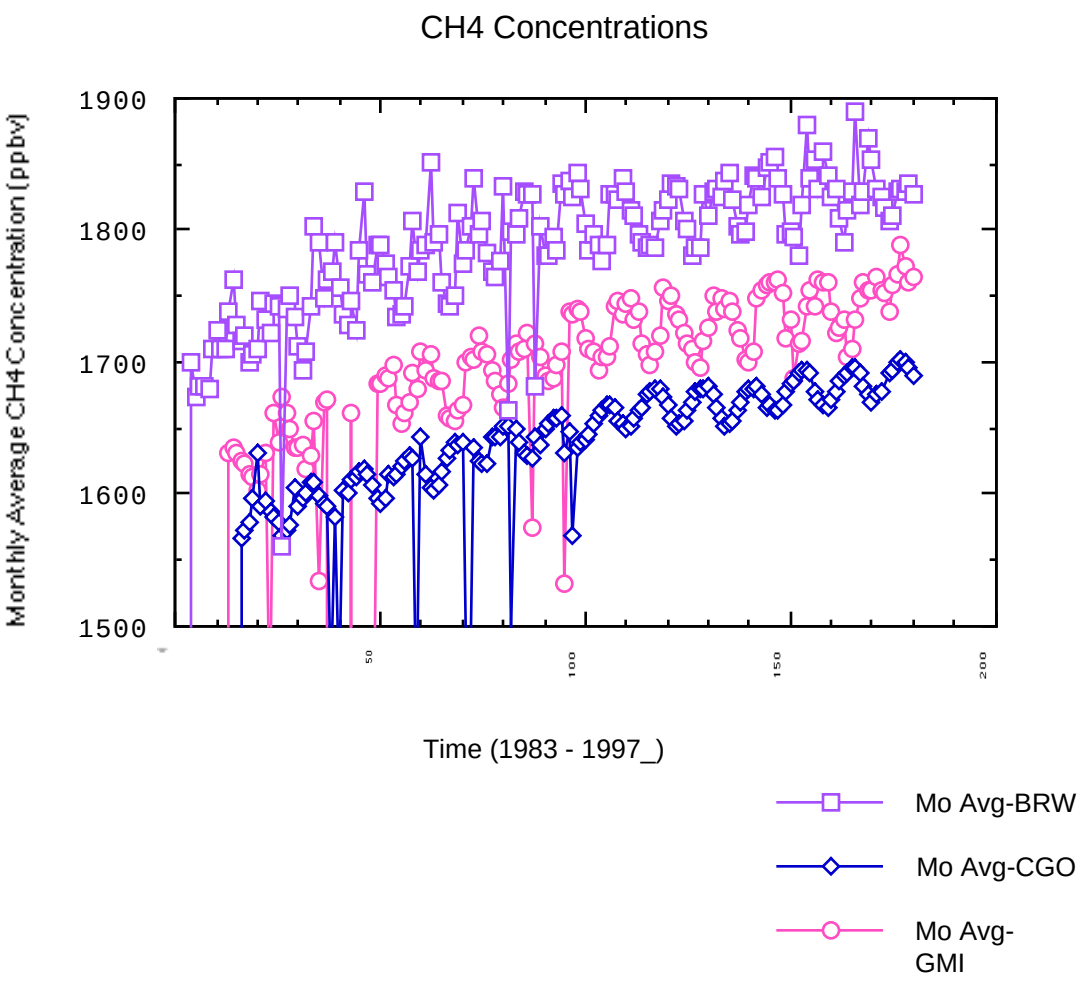
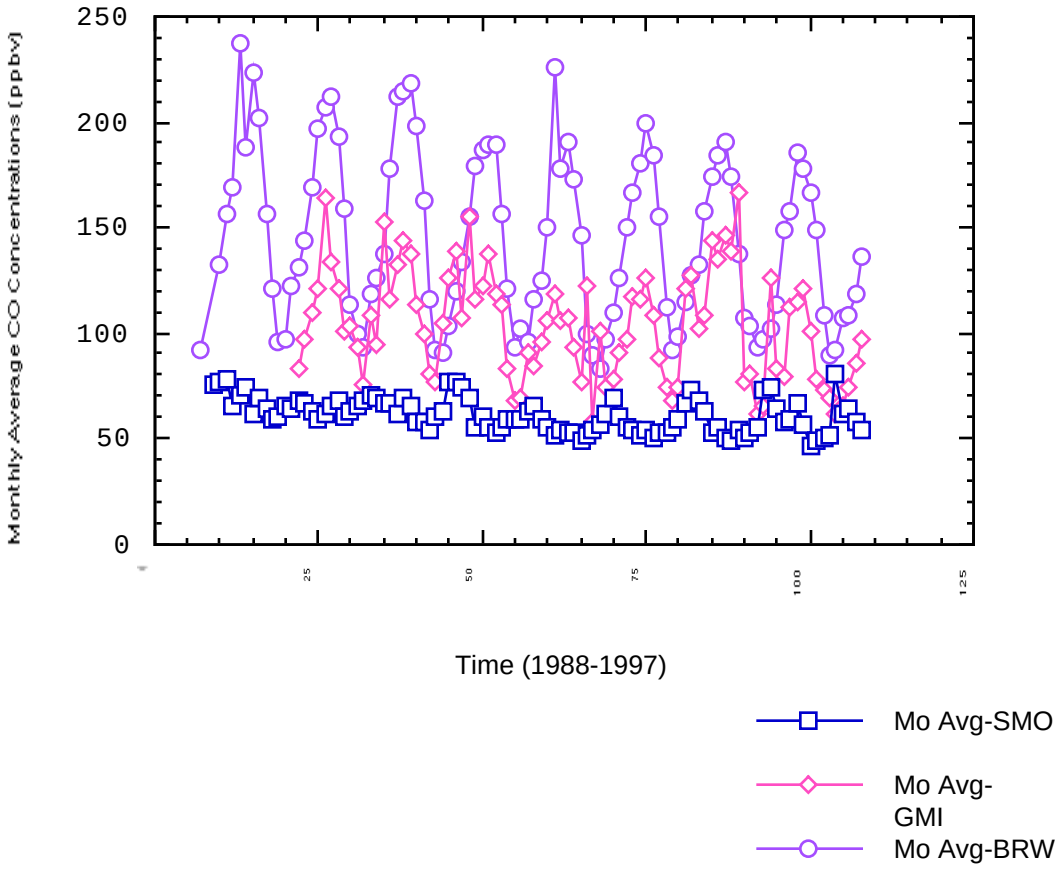
Objective:

To develop an understanding of the effects of CH_4, CO, and NMVOC emissions on OH, and feedbacks between OH, CH_4, and CO in order to more accurately determine emissions of these gases as well as Global Warming Potentials.

CH4 is a potent greenhouse gas, and its concentrations are increas



CO concentrations are also changing:



The sources of CH_4 are highly uncertain(Fung et al., 1991):

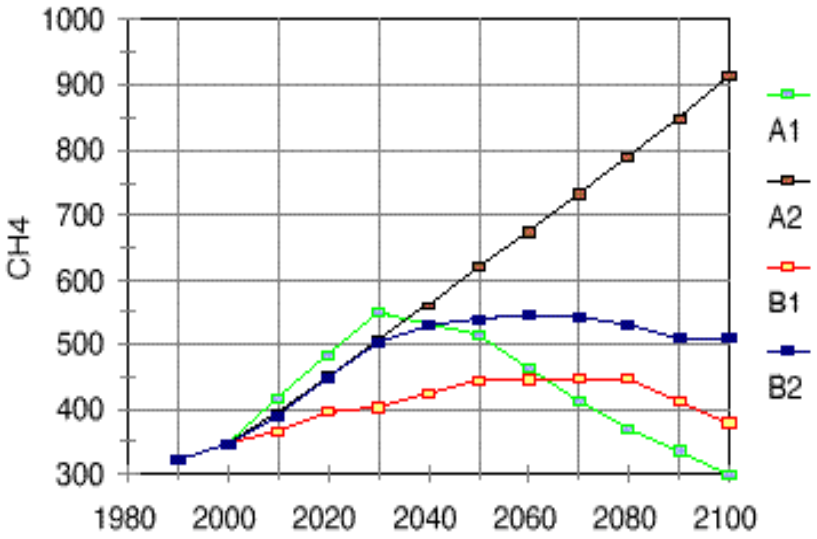
Source Type:	Source Strength (Tg/yr)	Uncertainty range
Wetlands	110	100-200
Bogs	30	
Swamps	40	100-200
Tundra	5	
Rice cultivation	50	60-170
Animals	80	65-100
Landfills	50	30-70
Venting of natural gas	50	
Pipeline leakage	50	25-50
Coal mining	50	25-45
Biomass burning	50	50-100
Termites	50	10-200
Hydrate/clathrate, Soviet	10	?
Hydrate/clathrate,zonal	10	?

Sources of CO are also poorly quantified:

Source Type:	Source Strength (Tg/yr)	Reference
Fossil fuel	525+/-100	Penner and Eddleman (1995)
Biomass burning	450+/-?	Liousse et al. (1996)
Ocean	16.5+/- 10	
Additional winter biomass source	380	Dignon et al. (1997)
Oxidation of isoprene	587+/-200	Guenther et al. (1995)
Plant emissions	100+/-50	
Soils	17+/-15	
Oxidation of CH_4		Model simulation

In the future, concentrations of both CH4 and CO may incr

CH4 and CO emissions (Tg CH4/yr) (IPCC, 1999)



OH concentrations depend on H_2O, O_3, NO_x, CO, CH_4 and NMOCs:

Main sources of OH:

$$O_3 + h\nu \rightarrow O_2 + O(^1D)$$
$$O(^1D) + H_2O \rightarrow 2OH$$
$$HO_2 + NO \rightarrow OH + NO_2$$

Main sinks of OH:

$$OH + CO \rightarrow CO_2 + H$$
$$OH + CH4 \rightarrow CO + \text{products}$$
$$OH + C_5H_6 \rightarrow 2.5CO + \text{products}$$
$$O_3 + OH \rightarrow HO_2 + O_2$$
$$OH + H_2O_2 \rightarrow HO_2 + H_2O$$
$$OH + HO_2 \rightarrow H_2O + O_2$$
$$OH + NO_2 \rightarrow HNO_3$$

The reaction of OH with CO accounts for most of the OH sink. Therefore, if CO concentrations increase, OH may decrease, causing increases in CH_4.

To evaluate the potential for CO emissions to affect CH_4, the system was simplified to:

$$d[CH_4]/dt = S_{CH4} - k_1 [OH] [CH_4]$$

$$d[CO]/dt = S_{CO} + k_1 [OH] [CH_4] - k_2 [OH] [CO] - d[CO]/dt_{soil\ uptake}$$

$$d[OH]/dt = S_{OH} - k_1 [OH] [CH_4] - k_2 [OH] [CO] - k_3 [OH] [X],$$

where $k_3[X]$ accounts for the sum of all the reactions for OH sinks that are independent of the CH_4-CO system, S_{OH} accounts for all reactions which are sources for OH. $k_3[X]$ and S_{OH} were diagnosed from a version of GRANTOUR that solves the full system of equations and, this 3-species model was solved using GRANTOUR with the CO and CH_4 source terms described in Tables 1 and 2. Additionally, in some simulations the feedback reaction of HO_2 with NO was included.

Results :

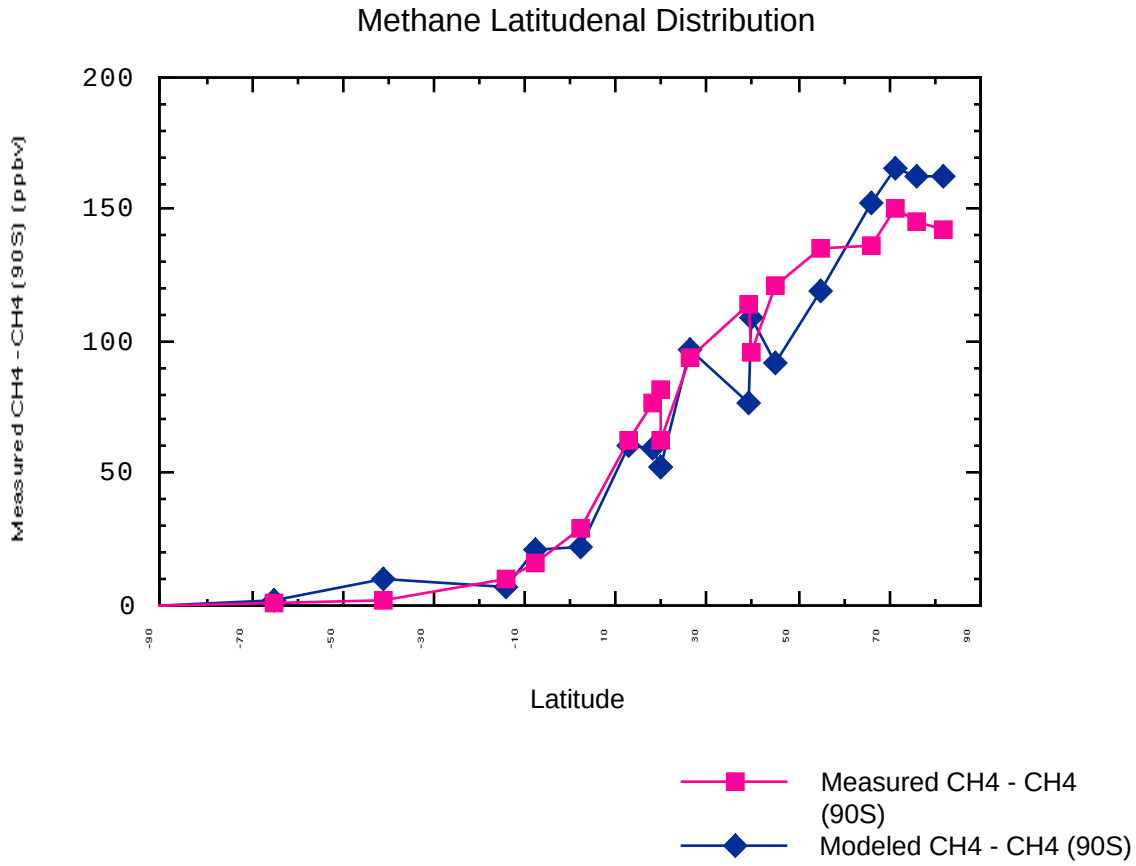
Average OH from CH_3CCl_3 analysis (Prinn et al., 1995) ($1x10^{-5}$ cm^{-3})

	90S – 30S	30 S - 0	0 – 30N	30N – 90N
205-500 mb	6.4	15.8	13.7	5.7
500–1000 mb	5.5	15.9	12.2	4.3

Average OH from model (no NMHC reactions) ($1x10^{-5}$ cm^{-3})

	90S – 30S	30 S - 0	0 – 30N	30N – 90N
205-500 mb	7.6	18.6	19.1	9.7
500–1000 mb	7.8	18.4	19.6	12.4

Latitudenal distribution of CH4:



The global warming potential of a gas is defined as:

$$GWP(c_i) = \frac{\int_0 a_i c_i(t)dt}{\int_0 a_{CO_2} c_{CO_2}(t)dt}$$

where a_i is the instantaneous radiative forcing (per unit mass) due to a unit increase in the concentration of trace gas *i*, and c_i is the concentration of the trace gas i remaining at time t after an initial impulse of that gas. The global warming potential is normalized by the radiative forcing caused by an increase of CO_2.

Global warming potential:

Direct global warming potentials for methane for time horizons of 20, 100 and 500 years.

Case	20 years	100 years	500 years
CH_4 Impulse Direct GWP	44.3	17.05	5.16

Global Warming Potentials for CO perturbations of CH_4.

Case	20 years	100 years	500 years
Global CO Impulse	3.2	1.2	0.4
Including HO_2+NO	2.4	0.9	0.3

Conclusions and future work:

With this simple model, OH concentrations appear to be too high relative to those expected from analysis of CH_3CCl_3 trends.

Additionally, the ratio:

$$\frac{[OH]_{NH}}{[OH]_{SH}}$$

is 1.2, while the analysis of Prinn et al., indicates a value of 0.8, which is also consistent with analysis based on ^{14}CO (Brenninkmeijer et al. (1992).

As a result CO and CH_4 concentrations are underpredicted.

Future versions of the model will examine the impact of NMOC emissions on OH, CO, and CH_4.

This should provide us with a better method for quantifying the effects of CO on CH_4 concentration and global warming potential.